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Dina Lake #1 Pygmy Whitefish (*Prosopium Coulteri*) Study, Stomach Contents Analysis, 2000

M. D. Stamford
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Compensation Program Fish Technical Committee.**

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Dina Lake #1 Pygmy Whitefish (*Prosopium coulteri*) Study

Stomach Contents Analysis, 2000

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Diet Analysis from Stomach Contents

This paper summarizes the methods and results obtained in the laboratory from stomach contents analysis of pygmy whitefish (*Prosopium coulteri*) samples from Dina Lake #1, located north of Mackenzie, British Columbia. The relative abundance of taxonomic groups within and among the stomach samples was used to determine the important foraging areas that were used by the fish during the summer of 2000. Consequently the organisms in the stomachs were taken to levels of taxonomy that enabled distinctions among ecotypes (largely benthic and limnetic invertebrates). Other data collected that pertain to the fish morphology, sex, sample times and sample sites are presented in McPhail and Zemplak (2001). Taxonomy of the items collected from the stomach contents were determined using keys from Pennak (1978), Merritt and Cummins (1996), Sandercock and Scudder (1996) and Green et al. (1997). Lidija Vidmanic (Private Consultant, Paleolimnologist and zooplankton taxonomy expert) confirmed identification of Copepoda suborders.

A total of 322 pygmy whitefish were sampled in 2000 and stomach contents were examined from 149 of these fish (Table 1). Stomach samples 1 to 150 were captured in June, 151 through 208 were captured in July, samples 209 through 262 were captured in September, and samples 263 through 322 were collected in October.

Table 1. Fish collection times and number of samples per trip.

Sample Trip Date	Number of Samples Collected	Sample Set Numbering
June	150	1 to 150
July	58	151 to 208
September	54	209 to 262
October	60	263 to 322
Total	322	

Processing Procedure

1. Fat content and parasite load were estimated by examining the stomach samples externally after they were removed from the sample vials and placed on a petri dish. Parasite load was divided into high (greater than 5 cysts) medium (2<5 cysts) and low (2 or fewer cysts) categories. Estimates of fat content were roughly ranked as low (L), medium (M), or high (H), according to the amount of adipose tissue covering the stomach exterior (Appendix 1). Stomachs from fish with high fat content were completely covered with adipose tissue. Those stomachs with low fat content were considered limited to ones with narrow strands of adipose tissue along the stomach exterior with the pyloric caeca being clearly visible. Once these estimates were recorded, the tissues surrounding the stomachs, including adipose tissue, cysts containing parasites, spleen, liver, pyloric cecea and intestine, were carefully removed in preparation for opening the stomach cavity.

2. Stomachs were opened longitudinally by carefully parting the stomach wall on opposite sides with forceps. Stomach fullness was classified into four categories (Appendix 1): 0% - 25% full (pyloric limb of stomach half full and cardiac limb empty), 25% - 50% full (pyloric limb full and cardiac limb empty), 50% - 75% full (pyloric limb full and cardiac limb half full), 75% - 100% full (both limbs of stomach full and distended). Some stomachs were distended but empty, suggesting their contents were regurgitated before excision from the fish specimens. Leakage of stomach contents into the sample vials was always associated with splits in the stomach wall.
3. Relative abundance of the taxa found in the stomach contents was estimated with the aim of examining the relative amount of effort each pygmy whitefish spent foraging on a given type of prey (Appendix 1). Each prey item was designated into one of four proportions of the total volume inside the stomach: 0% - 25%, 25% - 50%, 50% - 75%, 75% - 100%. On occasion, there were some rare (0% - 25%) or two moderately rare (25% - 50%) taxa found within a single sample. Nevertheless, the sum of all relative abundance estimates of taxa accounted for 100% of the total stomach contents for any given sample.

Results and Discussion

Parasite load, stomach fullness, and fat content of the stomach samples were recorded (Appendix 1) although only relative abundance estimates of prey organisms were considered in the following analysis. There were only a few empty stomach samples and these were some of the last samples collected (higher sample numbers) and may have been associated with spawning pygmy whitefish.

Three Classes of invertebrates within the Phylum Arthropoda were found in the pygmy whitefish stomach contents including Crustacea, Insecta, and Arachnoidea. Further taxonomy revealed these organisms were likely taken by pygmy whitefish that were foraging in benthic (including the littoral region) and limnetic (water column) habitats of the lake. The limnetic taxa were clearly the most abundant organisms within the stomach contents (Figure 1A) and were present in the greatest proportion of the pygmy whitefish stomach samples (Figure 1B). Among the limnetic taxa, the greatest proportion within and among the samples were Crustaceans that were further classified into two orders, Cladocera and Copepoda.

Cladocera genera included *Daphnia*, *Bosmina*, *Leptodora* and *Alona*. The latter three genera were found in low quantities in a few samples scattered throughout the series, although *Bosmina* were relatively abundant in the lower (June) sample numbers (1 through 100). They were likely ingested incidentally by fish that were targeting other prey in the water column (e.g. *Daphnia* and Copepoda; Figure 2 A and B). *Daphnia* were not highly represented in the June samples although they made up a large proportion (50% or greater) of the stomach contents and were present in most of the samples numbering greater than 100. Copepods were also abundant limnetic prey items and were classified into two suborders, Calanoida and Cyclopoida. Cyclopoids were abundant and often the only prey items present in the lower (June) sample numbers (roughly 1 through 150). A decreased abundance of Cyclopoid copepods coincided with the appearance and increased abundance of Calanoid

copepods and *Daphnia*, although they continued to show up periodically in some of the higher sample numbers. Calanoida were often the most abundant prey in the stomach contents although they were almost always found with *Daphnia* and other Cladocera.

This shift in the diet from Cyclopoid copepods to Calanoid copepods and *Daphnia* likely reflects the way in which these invertebrate groups partition their habitat in the lake. When found in sympatry, different copepod species partition their habitat either temporally or spatially although, presumably due to competitive exclusion, some lakes only sustain a single copepod species (Pennak 1989). If partitioning in Dina Lake #1 is spatial (i.e. the different copepod groups were abundant at the same time but at different locations) then greater abundance of one group in the stomach samples might reflect a foraging preference exhibited by pygmy whitefish. Alternatively, pygmy whitefish simply target the most abundant prey items and observed changes in abundance of certain prey organisms in the stomach contents reflects a similar change in abundance in the lake. A relationship between the prey types found in the stomach contents and pygmy whitefish sample locations might help distinguish between these hypotheses although future collections of stomach samples should be accompanied by quantitative sampling of invertebrates from the water column.

The remaining limnetic organisms included Hydracarina, Diptera pupae and Chaoboridae larvae that were relatively rare within and among the samples (Figure 2 A and B). These were seldom the most abundant organisms in the stomach contents and were often found randomly mixed with other more abundant groups like Cladocera or Copepoda, suggesting these were incidental prey items.

Periodically however, each of these organisms was the most abundant prey in the stomachs suggesting they were targeted by some pygmy whitefish schools. Some of these diptera pupae were so large that as few as five individuals could fill a stomach. Diptera pupae (most notably Chironomidae) often migrate through the water column in mass quantities towards the lake surface or lakeshore. These 'hatches' are often triggered at specific times by environmental cues such as water temperature and photoperiod (Merritt and Cummins 1996). As such, despite their periodic abundance, these organisms did not make up a larger proportion of the pygmy whitefish diet (Figure 2). Some of the chaoborus larvae present in the stomachs were close to pupation and were found together with other diptera pupae (some of which were likely chaoboridae) suggesting pygmy whitefish found them while foraging at night or in shallow littoral areas. Chaoborus pupae are exceptionally good swimmers and often escape fish predation by migrating at night from deep water to emerge as adults among shoreline macrophytes (Merritt and Cummins 1996). Alternatively, pygmy whitefish targeted chaoborus larvae incidentally while hunting for copepods and Cladocera as chaoborus larvae are also voracious predators of zooplankton (Cladocera and Copepoda).

Benthic taxa were composed mostly of insects from three orders (Diptera larvae, Trichoptera larvae, and Ephemeroptera nymphs) although one crustacean order (Amphipoda, most likely *Hyallela azteca*) was also found. All of these groups live in littoral regions of lakes among macrophyte vegetation where the water is warmer (Pennak 1989, Merritt and Cummins 1996). Benthic invertebrate groups were generally rare in the stomachs and were mixed randomly among more abundant limnetic taxa, suggesting pygmy whitefish forage periodically in littoral areas but they mostly target organisms swimming in the water column. Among benthic taxa, chironomid larvae were most commonly found mixed with limnetic taxa although some of them must have been foraged from the water column. They are often sampled among zooplankton that have been collected from the

water column in lakes (pers. obs.). Only two pygmy whitefish (sample numbers 109 and 274) were clearly foraging predominantly in the littoral zone prior to capture, as benthic invertebrates were the most common taxa in their stomach contents.

Absence of any organisms that have associations with the lake surface (e.g. terrestrial insects and adult aquatic insects) in any of the stomach samples suggests pygmy whitefish live primarily at depth in Dina Lake #1. Although this population of pygmy whitefish appear to forage predominantly in the water column, the presence of shallow water visual predators in Dina Lake #1 (e.g. *Couesius plumbeus*, *Oncorhynchus mykiss*, *Salvelinus fontinalis*) suggests the limnetic invertebrate community must undergo diel vertical migration in order to escape predation at the surface. Among the visual predators, pygmy whitefish likely have a remarkable ability to forage successfully under low light conditions given they are commonly taken in water deeper than seven meters (Mcphail and Lindsey 1970). If copepods and cladocerans in Dina Lake #1 migrate into deep water during the day then pygmy whitefish would have an abundant food source at times when it is unavailable to other visual predators. Furthermore, like their prey, diel vertical migration would enable pygmy whitefish to escape predation from piscivorous salmonids and birds at the surface.

Two forms of pygmy whitefish have been identified in western North America, a high gill raker form and a low gill raker form (McCart 1970). The high gill raker form most likely originated from a northern (Beringian) glacial refuge while the low gill raker form originated from a southwestern glacial refuge. The two forms are sympatric in a number of lakes in Alaska. In British Columbia, the low gill raker form appears to be confined to the Fraser, Skeena and Upper Peace watersheds and the high gill raker form has only been found in the upper Liard River and upper Yukon River (McCart 1970). Nevertheless, Carl et al. (1973) describes *P. coulteri* in British Columbia as having seven to ten dorsal fin rays, a character in association with the high gill raker form which has fewer dorsal fin rays than the low gill raker form (McCart 1970). It is possible that the distribution of high gill raker forms extends further south than described in the literature, which raises the probability that sympatric lineages exist but have yet to be described in the upper Peace watershed. The diet of the two forms is also distinct: the low gill raker form feeds on benthic invertebrates while the high gill raker form feeds on zooplankton. It is possible that there are sympatric forms of pygmy whitefish in Dina Lake #1 although the results from this diet study suggest the benthic feeding form is rare. Alternatively the benthic low gill raker form has a lower probability of being snared in the gill nets used to collect the samples for this study. Clearly further study is required to examine this sensitive and apparently rare species in Dina Lake #1 and other parts of the Williston watershed.

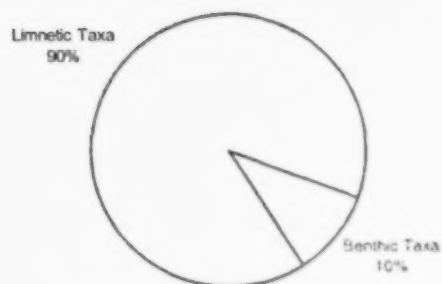
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A

Relative Abundance of Invertebrate Ecotypes Found in Pigmy Whitefish Stomach Contents



B

Proportion of Pigmy Whitefish Samples that Foraged in Different Lake Habitats

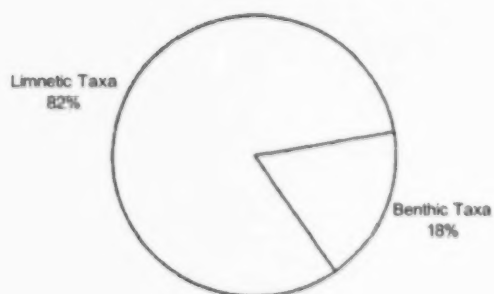
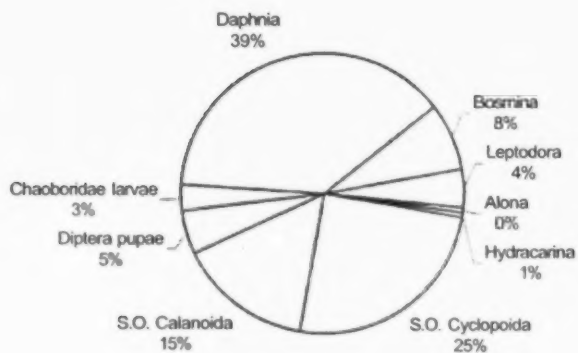


Figure 1: Relative abundance of invertebrate ecotypes found in the stomach contents (A) and among pygmy whitefish samples (B).

A

Relative Abundance of Limnetic Invertebrate Taxa Found in Pigmy Whitefish Stomach Contents



B

Proportion of Pigmy Whitefish Samples That Foraged on the Different Limnetic Invertebrate Taxa.

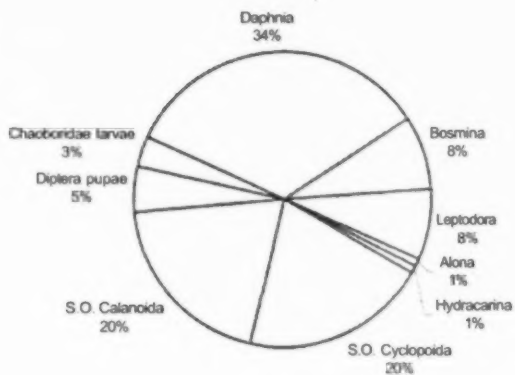
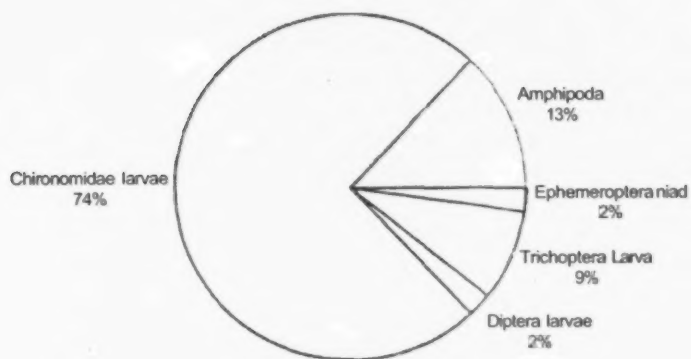


Figure 2: Relative abundance of limnetic invertebrate taxa found in stomach contents (A), and among pigmy whitefish samples (B).

A

**Relative Abundance of Benthic Invertebrate Taxa Found in
Pigmy Whitefish Stomach Contents**



B

**Proportion of Pigmy Whitefish Samples that Foraged on the
Different Benthic Invertebrate Taxa**

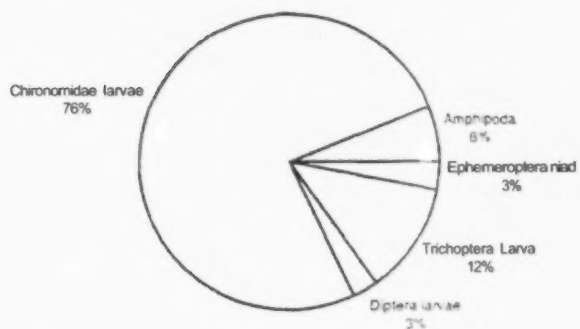


Figure 3: Relative abundance of benthic invertebrate taxa in stomach contents (A), and among pigmy whitefish samples (B).

Appendix 1

Relative Abundance Of Invertebrate Taxa Found In Each Pygmy Whitefish Stomach Sample

Fish No.	Stomach Fullness	Fat Content	Benthic Yaxa				Limnetic Yaxa					Hydracarina
			Ephemeroptera nial	Trichoptera Larva	Diptera larvae	Chironomidae larvae	Amphipoda Hyalella azteca	O. Euclopeda S.O. Calanoida	Diptera pupae	Chaoboridae larvae	Daphnia Bosmina Leptodora Alona	
1	50-75	M				0%-25%		75%-100%				
2	50-75	H						75%-100%			0%-25%	
3	50-75	M						75%-100%			0%-25%	
4	50-75	M						75%-100%			0%-25%	
5	50-75	M						75%-100%			0%-25%	
6	75-100	L						75%-100%			0%-25%	0%-25%
7	50-75	L			0%-25%			75%-100%			0%-25%	
8	50-75	H						75%-100%			0%-25%	
9	50-75	H						75%-100%			0%-25%	
10	75-100	H						75%-100%			0%-25%	
11	75-100	H						75%-100%			0%-25%	
12	50-75	H						75%-100%			0%-25%	
13	75-100	H				0%-25%		75%-100%			0%-25%	
14	50-75	H				0%-25%		75%-100%			0%-25%	
15	50-75	H						75%-100%			0%-25%	
16	50-75	H						75%-100%			0%-25%	
17	50-75	H				0%-25%		75%-100%			0%-25%	
18	50-75	M						75%-100%			0%-25%	
19	50-75	M				0%-25%		75%-100%			0%-25%	
20	50-75	M				0%-25%		75%-100%			0%-25%	
21	50-75	M						75%-100%			0%-25%	
22	50-75	H						75%-100%			0%-25%	
23	50-75	H						75%-100%			0%-25%	
24	50-75	H						75%-100%			0%-25%	
25	50-75	H						75%-100%			0%-25%	
26	50-75	H						75%-100%			0%-25%	
27	50-75	L						75%-100%			0%-25%	
28	50-75	L						75%-100%			0%-25%	
29	50-75	L						75%-100%			0%-25%	
30	50-75	L						75%-100%			0%-25%	
31	50-75	L						75%-100%			0%-25%	
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47	50-75	H						75%-100%			0%-25%	
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150	50-75	M						75%-100%			0%-25%	
151	50-75	M						75%-100%			0%-25%	
152	50-75	M</										

Fish No.	Stomach Fullness	Fat Content	Benthic Fauna				Limnetic Fauna						Hydracarina
			Ephemeroptera naad	Trichoptera Larva	Diptera larvae	Chironomidae larvae	Amphipoda Hyalella astrea	S.O. Cyclopoida 75%-100%	O. Eucyclopoida	Diptera pupae	Chaoboridae larvae	Daphnia Bosmina Leptodora Alona	
156	50-75	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
157	75-100	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
158	75-100	H						0%-25%	0%-25%	0%-25%		0%-25%	
159	75-100	H						0%-25%	0%-25%	0%-25%		0%-25%	
160	75-100	H						0%-25%	0%-25%	0%-25%		0%-25%	
161	75-100	H						0%-25%	0%-25%	0%-25%		0%-25%	
162	75-100	H						0%-25%	0%-25%	0%-25%		0%-25%	
163	50-75	H						0%-25%	0%-25%	0%-25%		0%-25%	
164	75-100	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
165	75-100	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
166	75-100	H						0%-25%	0%-25%	0%-25%		0%-25%	
167	75-100	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
168	75-100	L-M						0%-25%	0%-25%	0%-25%		0%-25%	
169	75-100	M						0%-25%	0%-25%	0%-25%		0%-25%	
170	75-100	M						0%-25%	0%-25%	0%-25%		0%-25%	
171	75-100	M						0%-25%	0%-25%	0%-25%		0%-25%	
172	75-100	M						0%-25%	0%-25%	0%-25%		0%-25%	
173	75-100	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
174	75-100	H						0%-25%	0%-25%	0%-25%		0%-25%	
175	75-100	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
176	75-100	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
177	50-75	M						0%-25%	0%-25%	0%-25%		0%-25%	
178	50-75	M						0%-25%	0%-25%	0%-25%		0%-25%	
184	25-50	H						0%-25%	0%-25%	0%-25%		0%-25%	
185	25-50	L						0%-25%	0%-25%	0%-25%		0%-25%	
186	50-75	H						0%-25%	0%-25%	0%-25%		0%-25%	
187	25-50	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
188	25-50	H						0%-25%	0%-25%	0%-25%		0%-25%	
189	50-75	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
190	25-50	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
191	0-25	H						0%-25%	0%-25%	0%-25%		0%-25%	
192	0-25	H						0%-25%	0%-25%	0%-25%		0%-25%	
197	25-50	M						0%-25%	0%-25%	0%-25%		0%-25%	
198	25-50	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
199	0-25	H						0%-25%	0%-25%	0%-25%		0%-25%	
200	25-50	H						0%-25%	0%-25%	0%-25%		0%-25%	
201	50-75	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
202	25-50	H						0%-25%	0%-25%	0%-25%		0%-25%	
203	50-75	H						0%-25%	0%-25%	0%-25%		0%-25%	
204	0-25	H						0%-25%	0%-25%	0%-25%		0%-25%	
205	50-75	H						0%-25%	0%-25%	0%-25%		0%-25%	
206	75-100							0%-25%	0%-25%	0%-25%		0%-25%	
207	50-75	H						0%-25%	0%-25%	0%-25%		0%-25%	
208	50-75	M						0%-25%	0%-25%	0%-25%		0%-25%	
209	0-25	L						0%-25%	0%-25%	0%-25%		0%-25%	
210	0-25	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
211	0-25	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
212	0-25	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
213	25-50	M-H						0%-25%	0%-25%	0%-25%		0%-25%	
214	amely	M-H						0%-25%	0%-25%	0%-25%		0%-25%	

Fish No.	Stomach Fullness	Fat Content	Benthic Fauna				Limnetic Fauna							
			Ephemeroptera larvae	Trichoptera larvae	Diptera larvae	Chironomidae larvae	Amphipoda <i>Hyalella azteca</i>	O. Cyclopoida S.O. Cyclopoida	Diptera pupae	Chaoboridae larvae	Daphnia Bosmina	Cladocera Lepidodora	Alana	Hydracarina
215	25-50	M-H							0%-25%				75%-100%	
216	empty	H							0%-25%				75%-100%	0%-25%
217	25-50	M							50%-75%				25%-50%	
218	empty	H							50%-75%				50%-75%	
219	50-75	M-H							50%-75%				50%-75%	0%-25%
220	50-75	H							50%-75%				50%-75%	0%-25%
221	empty	L												
222	25-50	M-H												
223	empty	M-H												
224	empty	H												
225	empty	M-H												
226	empty	M							50%-75%				50%-75%	
227	25-50	H							75%-100%				0%-25%	
228	0-25	H					25%-50%		25%-50%				0%-25%	
229	0-25	M-H							75%-100%				0%-25%	
230	0-25	H												
231	empty	L												
232	50-75	H							50%-75%				50%-75%	
233	0-25	H							50%-75%				50%-75%	
234	25-50	L							0%-25%				50%-75%	
235	0-25	M					0%-25%		25%-50%				50%-75%	
236	50-75	M-H							35%-50%				50%-75%	
237	25-50	H							50%-75%				50%-75%	
238	50-75	L-M							0%-25%				75%-100%	
239	50-75	L-M							0%-25%				50%-75%	
240	empty	L												
241	25-50	L-M							0%-25%				75%-100%	
242	50-75	M							50%-75%				25%-50%	
243	25-50	L-M							25%-50%				50%-75%	
244	0-25	M							25%-50%				50%-75%	
245	0-25	M-H							0%-25%				50%-75%	
246	0-25	M							50%-75%				50%-75%	
247	0-25	L-M							50%-75%				50%-75%	
248	75-100	L-M							0%-25%				75%-100%	
249	75-100	M							0%-25%				75%-100%	
250	75-100	M							0%-25%				75%-100%	
251	75-100	M							50%-75%				75%-100%	
252	75-100	M							0%-25%				75%-100%	
253	75-100	M							0%-25%				75%-100%	
254	75-100	M							0%-25%				75%-100%	
255	75-100	M							0%-25%				75%-100%	
256	75-100	M							0%-25%				75%-100%	
257	75-100	M							0%-25%				75%-100%	
258	75-100	M							0%-25%				75%-100%	
259	75-100	M							0%-25%				75%-100%	
260	75-100	M							0%-25%				75%-100%	
261	75-100	M							0%-25%				75%-100%	
262	75-100	M							0%-25%				75%-100%	
263	75-100	M							0%-25%				75%-100%	
264	75-100	M							0%-25%				75%-100%	
265	75-100	M							0%-25%				75%-100%	
266	75-100	M-H							0%-25%				75%-100%	
267	25-50	H							0%-25%				75%-100%	
268	50-75	L-M							0%-25%				75%-100%	
269	50-75	L-M							0%-25%				75%-100%	
270	empty	L												
271	25-50	L-M							0%-25%				75%-100%	
272	50-75	M							50%-75%				75%-100%	
273	50-75	M							50%-75%				75%-100%	
274	25-50	L-M							50%-75%				75%-100%	
275	25-50	L-M							50%-75%				75%-100%	
276	0-25	L-M							50%-75%				75%-100%	
277	50-75	M-H							0%-25%				75%-100%	
278	0-25	M-H							0%-25%				75%-100%	
279	0-25	M							0%-25%				75%-100%	
280	0-25	M							0%-25%				75%-100%	
281	0-25	M							0%-25%				75%-100%	
282	0-25	M							0%-25%				75%-100%	
283	75-100	L-M							0%-25%				75%-100%	
284	75-100	M							0%-25%				75%-100%	
285	50-75	L-M							0%-25%				75%-100%	
286	50-75	L-M							0%-25%				75%-100%	
287	75-100	L-M							0%-25%				75%-100%	
288	75-100	M							0%-25%				75%-100%	
289	50-75	M							0%-25%				75%-100%	
290	50-75	L-M							0%-25%				75%-100%	
291	50-75	L-M							0%-25%				75%-100%	
292	75-100	L-M							0%-25%				75%-100%	
293	75-100	L-M							0%-25%				75%-100%	
294	75-100	L-M							0%-25%				75%-100%	
295	75-100	L-M							0%-25%				75%-100%	
296	75-100	L-M							0%-25%				75%-100%	
297	75-100	L-M							0%-25%				75%-100%	
298	75-100	L-M							0%-25%				75%-100%	
299	75-100	L-M							0%-25%				75%-100%	
300	75-100	M							0%-25%				75%-100%	
301	75-100	M							0%-25%				75%-100%	
302	50-75	M-H							0%-25%				75%-100%	
303	25-50	L-M							0%-25%				75%-100%	
304	25-50	L-M							0%-25%				75%-100%	
305	50-75	M							0%-25%				75%-100%	
306	50-75	L-M							0%-25%				75%-100%	
307	75-100	L-M							0%-25%				75%-100%	
308	0-25	L-M							0%-25%				75%-100%	
309	0-25	L							0%-25%				75%-100%	
310	25-50	L-M							0%-25%				75%-100%	
311	0-25	L-M							0%-25%				75%-100%	
312	75-100	M							0%-25%				75%-100%	
313	25-50	L-M							0%-25%				75%-100%	
314	25-50	L-M							0%-25%				75%-100%	

